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	111212.00102

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

U.S. APPLICATION NO.

Unknown **09/936787**

INTERNATIONAL APPLICATION NO. PCT/US00/40011	INTERNATIONAL FILING DATE 17 March 2000	PRIORITY DATE CLAIMED 18 March 1999

TITLE OF INVENTION   METHOD FOR OPTIMIZATION OF VIDEO COVERAGE

APPLICANT(S) FOR DO/EO/US   Moshe Levin, Ben Mordechai

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ■ This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.

2. ☐ This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.

3. ■ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. (b) and PCT Articles 22 and 39(1).

4. ■ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. ■ A copy of the International Application is filed (35 U.S.C. 371(c)(2))

   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).

   b. ■ has been transmitted by the International Bureau.

   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)

6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).

7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))

   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).

   b. ☐ have been transmitted by the International Bureau.

   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.

   d. ☐ have not been made and will not be made.

8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).

10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.

12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. ☐ A FIRST preliminary amendment.

    ☐ A SECOND or SUBSEQUENT preliminary amendment.

14. ☐ A substitute specification.

15. ☐ A change of power of attorney and/or address letter.

16. ■ Other items or information:
    WO 00/56056

111212.00101/35271080v1

U.S. APPLICATION NO. Unknown **09/936787**	INTERNATIONAL APPLICATION NO. PCT/US00/40011	ATTORNEY'S DOCKET NO. 111212.00102

17. ■ The following fees are submitted:

CALCULATIONS PTO USE ONLY

BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5)):

Search Report has been prepared by the EPO or JPO $860.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) $690.00

No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) $1000.00

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $690.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $100.00

ENTER APPROPRIATE BASIC FEE AMOUNT = $690.00

Surcharge of $130.00 for furnishing the oath or declaration later than ☐20 ■30 months from the earliest claimed priority date (37 CFR 1.492(e)). $130.00.

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total Claims	6 - 20 =	0	X $18.00	$0
Independent Claims	2 - 3 =	0	X $80.00	$0
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $260.00	$
TOTAL OF ABOVE CALCULATIONS =				$820.00

Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28). $.

SUBTOTAL = $410.00

Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). + $

TOTAL NATIONAL FEE = $410.00

Fee for recording the enclosed assignment (37 CFR 1 21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28,3.31). $40.00 per property   + $

TOTAL FEES ENCLOSED = $410..00

	Amount to be refunded:	$
	charged:	$

a. ☐ A check in the amount of $ to cover the above fees is enclosed.

b. ■ Please charge my Deposit Account No. 23-2185 in the amount of $410.00 to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ■ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 23-2185 . A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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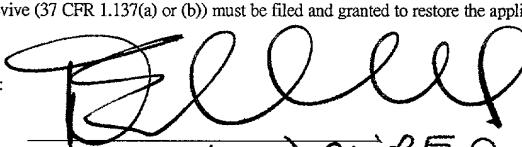
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6/parts

METHOD FOR OPTIMIZATION OF VIDEO COVERAGE

REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Application No. 60/124,931,

filed March 18, 1999, whose disclosure is hereby incorporated by reference in its entirety into

5   the present disclosure.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to video coverage of a given space using fixed cameras

in which each camera has a predetermined three-dimensional orientation (azimuth and

10   elevation) and more particularly to a method of optimizing the placement and angular

orientation of the cameras.

Description of the Related Arts

Real and still remote video systems cover a given space by a multiplicity of video

cameras. The video cameras may be fixed or mobile. Firstly, each camera has a location and

15   angular orientation that may be defined by the vector (x, y, z, θ, ϕ) where x, y, z are the three-

dimensional coordinates and θ and ϕ are the azimuth and elevation of the camera line of sight

are relative to the x, y, z coordinate system. Secondly, we will define $\alpha_{\theta,i}$ and $\alpha_{\phi,i}$ as the

maximum field of view for each camera and c as a cost attribute. We will define the space to

be covered as a three-dimensional surface of points $x_k y_k$ defined by a height coordinate z for

20   each $x_k y_k$. A set of N cameras will be defined by M, an $N \times 8$ matrix. Mobility is defined as a

change in any one of the above mentioned vector (or matrix) values. The level of mobility is

determined by the mechanical mounting of the camera.

A coverage priority level is defined such that for each point (x_j, y_j, z_j) a priority of

coverage value, P_j, is assigned.

Further we define a coverage level criterion CL that for each given matrix M

represents the quality of coverage.

5   The prior art provides no efficient way to optimize CL. Trial and error should not be

relied upon.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to determine the best location and angular

orientation for a given set of cameras, best covering a predetermined three-dimensional area.

10   The invention is based on building a computerized three-dimensional model (like a DTM

map) of the area to be covered, setting coverage priorities to each point on the three-

dimensional surface and using an efficient combination of mathematical optimization

techniques to set the best location of cameras required to obtain a predefined level of quality.

It is a second object of this invention is to determine the best subset of cameras,

15   locations and orientation, chosen from a predefined set of cameras. That is, the number of

cameras is optimized along with their positions and angular orientations. The selected set will

have minimal total cost while maintaining a predefined criteria of coverage.

The present invention provides a method of selecting a plurality of fixed camera

locations and angular orientations and which in one embodiment is capable of reducing the

20   total required number of cameras to cover a given three dimensional space. Each single

camera has a mechanical installation point and fixed orientation (elevation and azimuth

angles relative to a chosen coordinates system). The cameras are capable of optical zoom in

and zoom out and electronic selection of the view within the mechanical limitation of the

camera mount. The method determines the number of cameras required to cover a

predetermined space (hall, sports field or any other defined location) within required

performance criteria. Further, the method provides a mechanical mounting location for each

of the selected cameras, and the installation orientation.

The cameras can be of the sort that have electronic navigation capabilities only. This

5   invention can be used with remote access real and still video applications.

The optimization problem for a given space is to find the number N of cameras out of

the set of $K \geq N$ cameras, and the values $(x, y, z, \theta, \phi, \alpha_{\theta_i}, \alpha_{\phi_i}, c_i)$ $0 < i < N$ which will meet a

predetermined level of CL. In addition, the optimization technique will optimize the

coverage for a given level of coverage.

10   The optimization technique utilized is a combination of genetic algorithms and

simulated annealing.

Genetic algorithms are local search methods where the neighborhood generation

mechanism is inspired by real life process of genetics and evolution. In particular, the current

sub-optimal solution is modified by "splicing" and "mutation" to obtain the next generation

15   solutions.

Simulated annealing is a simulated technique, which allows to provide an efficient

search with a mechanism allowing not to be stuck in one local minimum.

The combination allows exploitation of both optimization techniques to produce a

robust fast converging solution.

20   **BRIEF DESCRIPTION OF THE DRAWINGS**

The above and other objects, features and advantages of the present invention will

become apparent from the following description, taken in conjunction with the accompanying

drawings in which:

Fig. 1 is a view for describing the three-dimensional model of the area to be covered

by the plurality of cameras.

Fig. 2 is a view of the three-dimensional model describing the ceiling of the above

model. The ceiling here means the maximum allowable height of the camera.

Fig. 3 is a view of all the parameters of the camera.

Fig. 4 depicts a high-level flowchart of the suggested method.

Fig. 5 depicts the camera footprint calculation.

Fig. 6 describes the recombination process.

DETAILED DESCRIPTION OF THE INVENTION

Invention Overview

The present invention will hereafter be described with reference to the accompanying

drawings.

Fig. 1 is a view for describing the three-dimensional model 100 of the area to be

covered by the plurality of cameras 102. For each pair of coordinates x, y we define a height

z. The vector (x,y,z) defines a point in space which is the surface to be covered. The surface

here can describe the ground level or the outside of the building which the system has to

cover.

Fig. 2 is a view of the three-dimensional model 200 describing the ceiling 202 of the

above model 100. The ceiling here means the maximum allowable height of the camera.

This value can be set from the actual height of the area roof, the maximum height determined

by safety reasons, the maximum height of a camera carrying construction. The ceiling is

defined by the vector (x,y,z_m), which sets the boundary conditions for the optimization

algorithm procedures.

Fig. 3 is a view of all the parameters of the camera 102:

x   The x location of the camera.

y   The y location of the camera.

z   The z location (height) of the antenna.

θ   The azimuth of the camera, relative to the x axis.

5   φ   The elevation of the camera, relative to the x,y plane.

Fig. 4 is a high level description of the method according to either of the preferred

embodiments to be set forth below. First we input a three-dimensional view of the area to be

covered which is the set of points (x,y,z) (step 402). Then we input the ceiling of the area

which sets the boundary condition for the location of the cameras (x,y,z_m) (also step 402).

10   Further, we input the coverage priority for each point on the surface P(x,y,z) (step 404).

The next step is to define the optimization parameters (details are discussed later)

(step 406). These parameters include (but are not limited to): number of iteration for the

genetic algorithms, algorithm parameters, number of output solutions, number of iteration of

the simulated annealing simulation parameter.

15   The genetic algorithm is activated to produce several solutions (step 408). For each

solution simulated annealing technique will be used to improve the quality of the solution

(step 410).

Fig. 5 describes the method by which the coverage of a single camera is calculated.

According to the view field, the presence or absence of each line of sight 502 is analyzed

20   from each point in the area.

Three-dimensional model of the area to be covered

The areas to be covered are defined by a three-dimensional model. The model is a set

of a finite number of vectors (or points in space). The model is typically (but not necessarily)

defined by a polygon that bounds the x,y plane and a resolution which sets the horizontal

distance between any two adjacent points. The same structure applies to the ceiling of the model which can be viewed as a second layer in a three-dimensional map and to the priority of coverage criteria which is attached to each three-dimensional point.

Higher quality results can be obtained if a second layer of "roof level" polygons is available in a matrix format. Such a layer can improve significantly the accuracy of the model, and hence the quality of the coverage.

An intermediate set is defined as $L(x,y,z)$. For each point in the model, and a given set of cameras position and space orientation, $L(x,y,z)$ is defined as the number of cameras that have lines of sight to (x,y,z). Under this definition $L(x,y,z)=0$ means that the specific point is not covered by any of the cameras.

Coverage quality calculation

The coverage quality will be calculated by the following formula:

$$CL = \frac{\sum_{x,y,z} L(x,y,z)^{k1} \cdot P(x,y,z)^{k2}}{\sum_{x,y,z} P(x,y,z)^{k2}}$$

where k_1 and k_2 are calibration factors used to calibrate the relevant importance of the various points. A large k_1 optimizes the coverage with emphasis on coverage diversity, i.e., several cameras for each point on the model. A small k_1 optimizes the system to have at least one camera over each point. Similarly, a large k_2 optimizes the coverage with strong advantage to the high priority points, while a small k_2 lessens the impact of priority for a given coverage.

Two preferred embodiments will now be set forth. In the first, the number of cameras is given; in the second, the optimization determines a cost-effective number of cameras.

1)   Optimization method: a given set of cameras

Setting global optimization parameters

The optimization parameters to be set are:

Iter_genetic   number of genetic algorithm iterations

Num_of_iter_solutions   number of solutions (M matrixes) that will be generated

by the genetic algorithm.

Iter_annealing   number of simulated annealing algorithm iterations (for

each of the Num_of_iter_solutions.

For iter_genetic=0, the optimization procedure will not include the genetic algorithm

phase and the required number of intermediate number of solutions determined by the

parameter num_of_iter_solutions will be generated automatically.

If the number of the simulated annealing iterations as defined by the parameter

Iter_annealing is set to zero, the parameter Num_of_inter_solutions will automatically be set

to 1. The selected M matrix will be the result of the genetic algorithm.

Genetic algorithm to optimize three-dimensional coverage for a given set of cameras

Algorithm local parameters:

Size_of_population - number of feasible solutions to be used in the simulation

Differential_step - (dx_i, dy_i, dz_i, $d\theta_i$, $d\phi_i$) the differential step for each variable

Local_search_iteration - number of local search iterations

mutation_probability - the probability that a specific value will be changed in the

mutation phase.

Urv - intermediate parameter, random variable.

power_of_bias - the urv defined earlier is raised to the power of power_of_bias and provide adjustment to the level of randomness in the selection process. For power_of_bias=0 no randomness is introduced to the process.

The algorithm's flow

5   **Step 0 - init:**

Define randomly a set of size_of_population M feasible matrixes.

Repeat steps 1-4 iter_genetic interations

Step 1 - local search

For each matrix M out of the size_of_population number of matrixes, repeat.

10   Local_search_iteration number of iterations:

1.1   Calculate the coverage level indicator CL

1.2   Calculate the coverage level indicator CL for $(N*5)$ differential moves, each defined by the size of the relevant value in the differential_step parameter.

1.3   Change the value of the matrix which generated the higher level of CL,

15   the change of the value will be in the size of: new_value = old_value - differential_step$*(CL_{new}-CL_{old})$, where the differential step is selected to the appropriate variable under consideration.

1.4   If $(CL_{new}-CL_{old})=0$, stop.

At the end of this step we have size_of_population.

20   **Step 2 - Mutation**

For each value of each matrix (total of size_of_population$*N*5$ values) determine with probability level of mutation_probability whether this specific value will be changed.

For each of the to be changed values, calculate a new matrix with the specific value according to the following equation.

25   New_value = Old_value + random number.

Step 3 - Recombination

Randomly select a number_of_combination subset of matrix pairs (M_1, M_2). From each pair of matrixes create a new matrix according to any of several combination mechanisms. One of them is described in the following recombination rules, describing the "breeding" process:

3.1   Calculate N integer random variables B_i, $1 < i < 5$.

3.2   The new matrix will be constructed out of the pair where for each vector (camera location) the first B_i elements will be taken from the matrix M_1 and the following $5-B_i$ elements will be taken from the matrix M_2.

Fig. 6 depicts the recombination process for a matrix of 5 cameras.

Step 4 - Survivor selection

Steps 2 and 3 created a set of up to $2S+S^2$ possible matrixes which stands for the cameras' positioning and orientation, where S stands for the size_of_population variable. Out of this population we select a next population of size_of_population solutions or cameras positioning according to the following procedure.

4.1   For each matrix calculate CL.

4.2   Multiply CL by a random bias factor: $CL_B = CL*(urv^{power\_of\_bias})$ where urv is a random variable distributed uniformly over the range (0,1] and power_of_bias controls the effect of the random variable. If power_of_bias = 0, then $CL_B=CL$ and there is no effect to the random factor.

4.3   Sort the population according to CL_B.

4.4   Select the size_of_population highest ranking variables as the next generation population.

Step 5 - Selection of intermediate solutions

If the number of iteration for the simulated annealing is set to zero (iter_annealing=0),

the highest rank solution (matrix) is the selected solution for the given number of cameras.

If the number of iterations is higher than zero, then from the population of

size_of_population matrixes, select num_of_iter_solutions highest ranking matrixes as input

5   to the next phase.

Simulated annealing procedure to further improve three-dimensional coverage

Algorithm local parameters:

T = temperature

Search_radius = search radius around the reference solution.

10   ## The algorithm's flow

For each of the num_of_iter_solutions matrixes repeat the following steps

inter_annealing iterations:

Step 1 - Generate randomly a matrix in a distance (per variable) less than search_radius from

the reference matrix.

15   **Step 2** - Calculate the resulting coverage level CL_{new}.

Step 3 - if CL_{new} is lower then CL then the new matrix will be the new reference. Otherwise,

the new matrix will be selected as the reference matrix with a probability of $e^{-(CL_{new}-CL)/T}$. This

selection mechanism allows actual searching of global minimum and prevents locking in

local minimum.

20   **2) Optimization method: selecting a subset of cameras to meet a required coverage level**

In this case, the genetic algorithm is modified to handle selection of a subset of

cameras out of a given set of cameras. Various cost functions can be used to sort the tested

matrixes. In the following section, we describe the modified genetic algorithm. We

essentially describe the difference between the algorithm described earlier and the required

algorithm.

The coverage-cost criteria

Discussing selection of a subset of cameras with several cost levels we have to modify

the coverage level to include costs:

$$CL_C = \left(\frac{CL}{CL_0}\right)^{r_1} \left(\frac{TC_0}{TC}\right)^{r_2}$$

where:

- CL_C is the generalized quality of coverage.

- CL is the previously defined quality of coverage.

- CL_0 is a threshold level of CL.

- TC is the total cost of the cameras.

- TC_0 is a threshold level of the cost.

- r_1 depicts the relative influence of the quality of coverage as measured earlier. For

$r_1{=}0$ the actual cost of the cameras will be the only factor. For $r_1{>>}1$, CL values higher than

CL_0 have significant advantage.

- r_2 depicts the relative influence of the cameras cost. For $r_2{=}0$, the quality of coverage

will be the only factor. For $r_2{>>}1$ TC values lower than TC_0 have significant advantage.

The algorithm's flow

Step 0 - init:

Define the set C of available cameras, each with 6 parameters (adding camera cost to

the previous definition)

Define N as an initial guess on the required number of cameras to meet the coverage

generalized quality criterion CL_C.

Define randomly a set of size_of_population feasible matrixes each with N vectors (N

cameras).

5   Set the two-dimensional optimization parameters r_1, r_2.

Repeat steps 1-4 inter_genetic iterations.

<u>Step 1 - local search</u>

This step remains unchanged since the local search is done on the per matrix

calculation and the cost component is not relevant here.

10   For each matrix M out of the size_of_population number of matrixes, repeat

Local_search_iteration number of iterations:

1.1   Calculate the coverage level indicator CL.

1.2   Calculate the coverage level indicator CL for (N*5) differential moves, each

defined by the size of relevant value in the differential_step parameter.

15   1.3   Calculate the cost of the system: the sum of the sixth column update.

1.4   Change the value of the matrix which generated the higher level of CL, the

change of the value will be in the size of: new_value = old_value - differential_step*(CL_{new}-

CL_{old}), where the differential step is selected to the appropriate variable under consideration.

1.5   If (CL_{new}-CL_{old})=0, stop.

20   At the end of this step we have size_of_population.

<u>Step 2 - Mutation</u>

This step is the first step in the creation of matrixes with different sizes (variable

numbers of cameras).

2.1   <u>Location Change</u>: For each value of each matrix (total of size_of_population*N*5

25   values) determine with probability level of mutation_probability whether this specific value

will be changed. For each of the values to be changed, calculate a new matrix with the specific value according to the following equation: New_value=Old_value + random number.

2.2   Add/Remove Cameras: Generate a random number out of a normal distribution with average μ and standard deviation σ, add this number for the current number of cameras in the matrix and round the results. If the addition results is lower than the current number of cameras, select randomly the required number of cameras and remove. If the addition result is higher than the current number of cameras, add the required number of cameras selecting randomly from the set of feasible cameras C.

Step 3 - Recombination

This step creates matrixes with different sizes (variable numbers of cameras).

Randomly select a number_of_combinations subset of matrix pairs (M_1, M_2). M_1 and M_2 can be of different sizes, N_1 and N_2. From each pair of matrixes create a new matrix according to any of several combination mechanisms which can change the size of the result matrix. One of them is described in the following recombination rules:

3.1   Generate randomly N_{new} the number of cameras in the result matrix M. Without loss of generality we assume: $N_1 < N_{new} < N_2$.

3.2   Calculate N_{new} integer random variables B_i, $1 < i < 5$.

3.3   The new N_1 elements of the matrix will be constructed out of the pair where for each vector (camera location) the first B_i elements will be taken from the matrix M_1 and the following $5-B_i$ elements will be taken from the matrix M_2.

3.4   The remaining $N_{new}-N_1$ elements will be constructed by randomly "breeding" the $N_{new}-N_1$ elements of N_2 with random selection of vectors in M_1.

Step 4 - Survivor selection

The above described process results in a variable size population, i.e., coverage

solutions with variable number of cameras. The survivor selection handles matrixes with

variable numbers of cameras as well.

Steps 2 and 3 created a set of size of up to $2S+S^2$ possible matrixes which stand for

cameras positioning and orientation, where S stands for the size_of_population variable. Out

of this population, we select a next population of size_of_population solutions positioning

· according to the following procedure:

4.1   For each matrix calculate CL_C.

4.2   Multiply CL_C by a random bias factor: $CL_{BC} = CL_C*(urv^{power\_of\_bias})$

where urv is a random variable distributed uniformly over the range (0,1], and power_of_bias

controls the effect of the random variable. If power_of_bias=0, then $CL_{BC}=CL_C$ and there is

no effect to the random factor.

4.3   Sort the population according to CL_{BC}

4.4   Select the size_of_population highest ranking variables as the next generation

population.

Simulated annealing procedure

The simulated annealing procedure is done separately on each of the genetic algorithm

suggested matrixes. As a result, these procedures do not need to handle variable sizes of

matrixes.

The above procedures can be carried out on any suitable computing device, such as a

suitably programmed IBM-compatible microcomputer. An output (e.g., a display or a

printout) can provide the optimized positions and angular orientations of the cameras, as well

as the optimized number of cameras in the second embodiment. Those skilled in the art who

have reviewed the present disclosure will readily appreciate which hardware and software are required; therefore, such details will not be set forth here.

While two preferred embodiments of the present invention have been set forth above, those skilled in the art who have reviewed the present disclosure will readily appreciate that

5   other embodiments can be realized within the scope of the present invention. For example, while specifics of the genetic and simulated annealing algorithms have been set forth, other appropriate algorithms can be used instead. Therefore, the present invention should be construed as limited only by the appended claims.

What is claimed is:

1. A method for determining locations and angular orientations of a set of cameras to cover a predetermined volume, the method comprising:

(a) determining a number of said cameras;

(b) determining at least one intermediate solution through a genetic algorithm; and

(c) determining a solution from the at least one intermediate solution through a simulated annealing algorithm.

2. The method of claim 1, wherein step (b) comprises:

(i) determining a plurality of random initial solutions;

(ii) performing a local search around each of the random initial solutions to find a locally optimized solution;

(iii) applying a random mutation to each of the locally optimized solutions to obtain a mutated solution;

(iv) recombining the mutated solutions to obtain recombined solutions;

(v) sorting the recombined solutions by coverage level; and

(vi) selecting a number of the recombined solutions having the highest coverage levels for the simulated annealing algorithm.

3. The method of claim 2, wherein step (c) comprises, for each of the recombined solutions selected in step (b)(vi):

(i) randomly generating a new solution which is separated from the recombined solution by less than a predetermined search radius;

(ii) calculating a coverage level of the new solution; and

(iii) reiterating steps (c)(i) and (c)(ii) until a globally optimized solution is reached.

4. The method of claim 1, wherein step (b) comprises using the genetic algorithm to optimize the number of cameras determined in step (a).

5. The method of claim 4, wherein step (b) comprises:

(i) determining a plurality of random initial solutions, each using the number of cameras determined in step (a);

(ii) performing a local search around each of the random initial solutions to find a locally optimized solution;

(iii) applying a random mutation to each of the locally optimized solutions to obtain a mutated solution, the random mutation comprising a random mutation in the number of cameras in each of the locally optimized solutions;

(iv) recombining the mutated solutions to obtain recombined solutions;

(v) sorting the recombined solutions by coverage level; and

(vi) selecting a number of the recombined solutions having the highest coverage levels for the simulated annealing algorithm.

6. The method of claim 5, wherein step (b)(iv) comprises, when two of the mutated solutions having different numbers of cameras are to be recombined, randomly generating a new number of cameras which is between the different numbers of cameras of the two mutated solutions to be recombined.
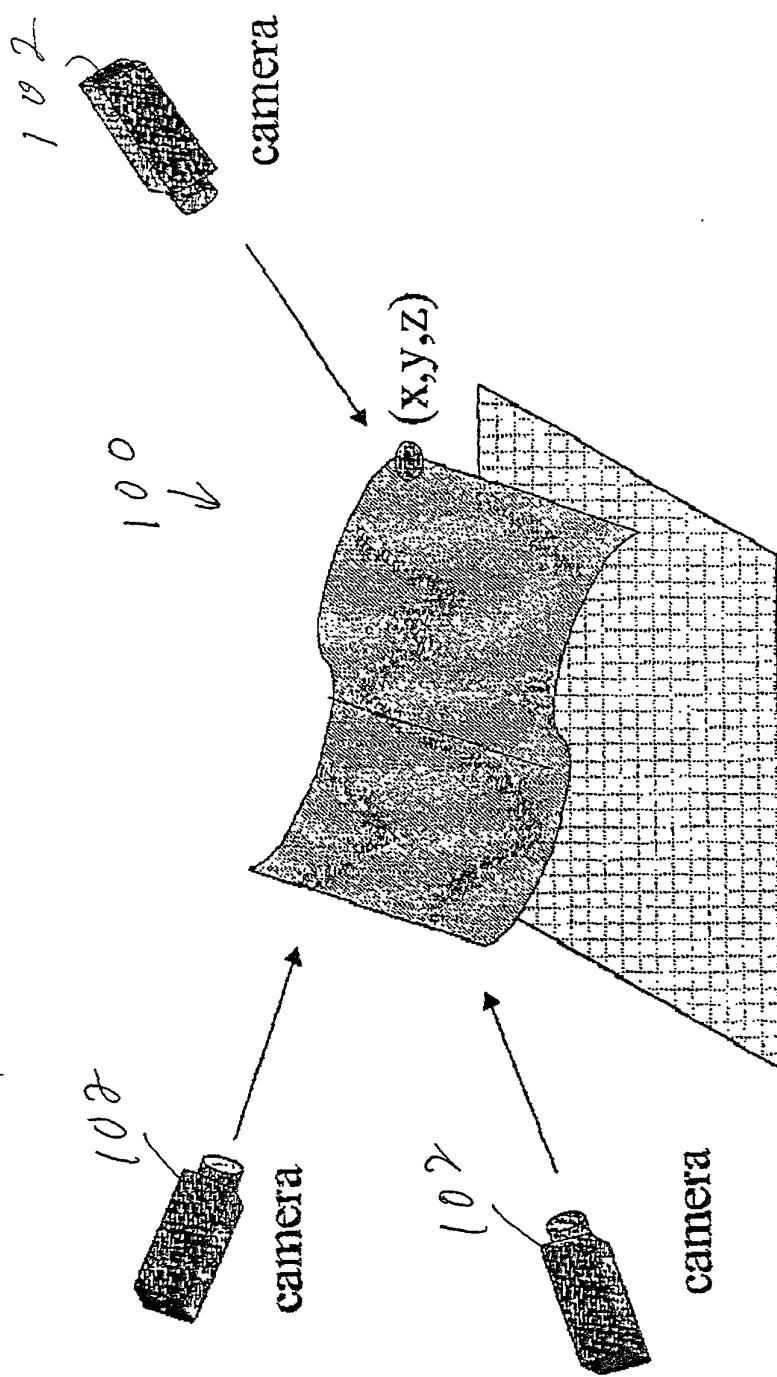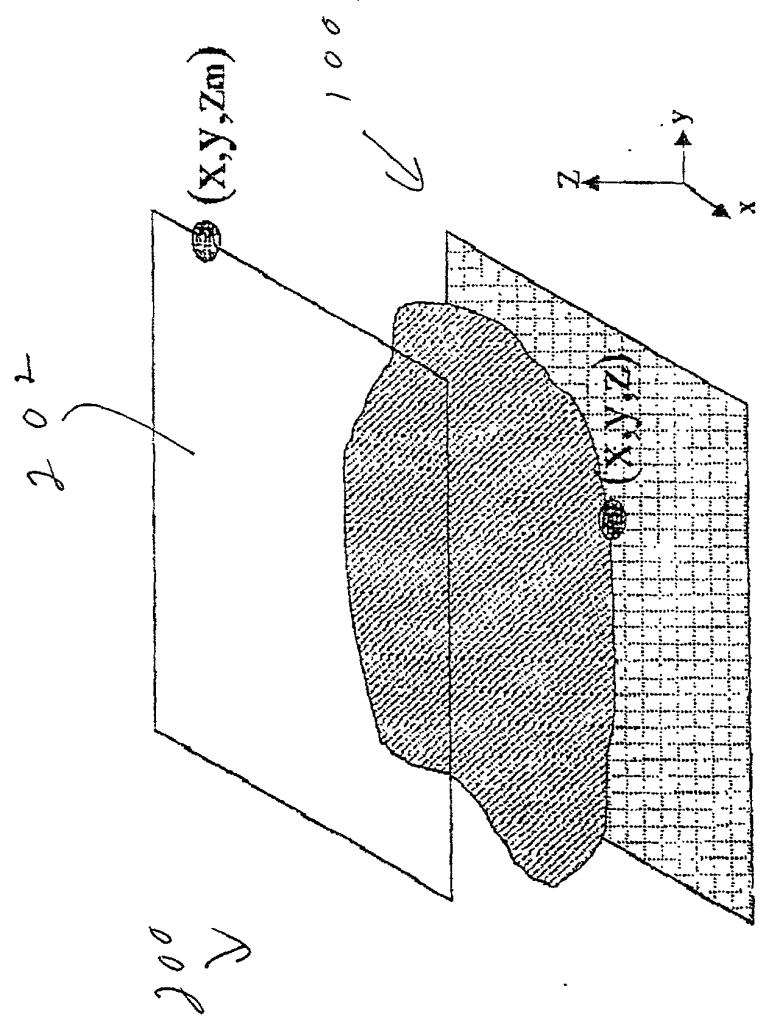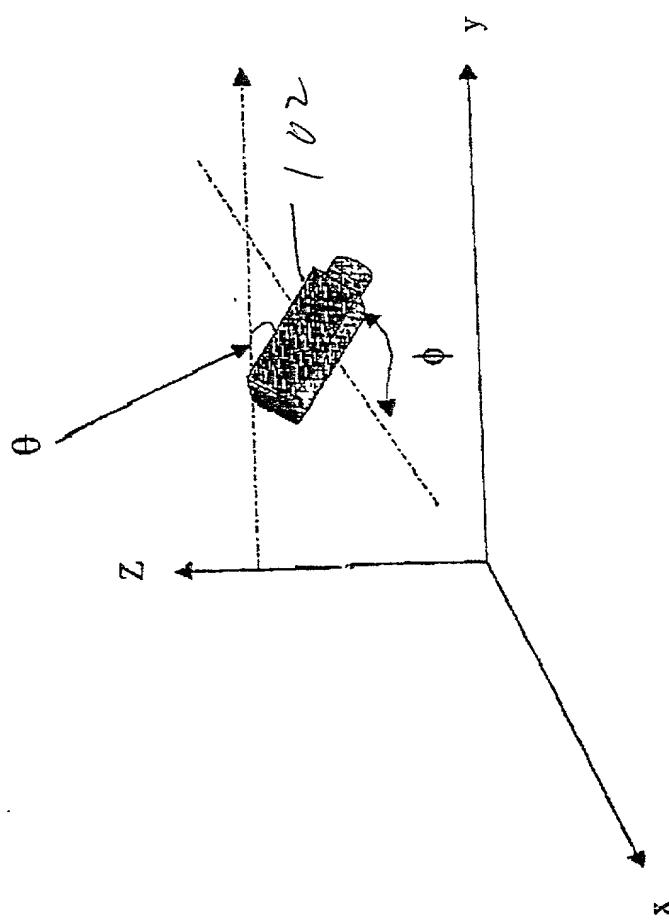
1/6

camera

102

(x,y,z)

100

camera

102

camera

102

Fig. 1

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Fig. 2

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Fig. 3

High level description

Input area description (x,y,z), (x,y,z$_m$) 402

Input coverage priorities P(x,y,z) 404

Set optimization process parameters 406

Run genetic optimization algorithm produce N$_G$ number of solution 408

To each solution operate simulated annealing 410
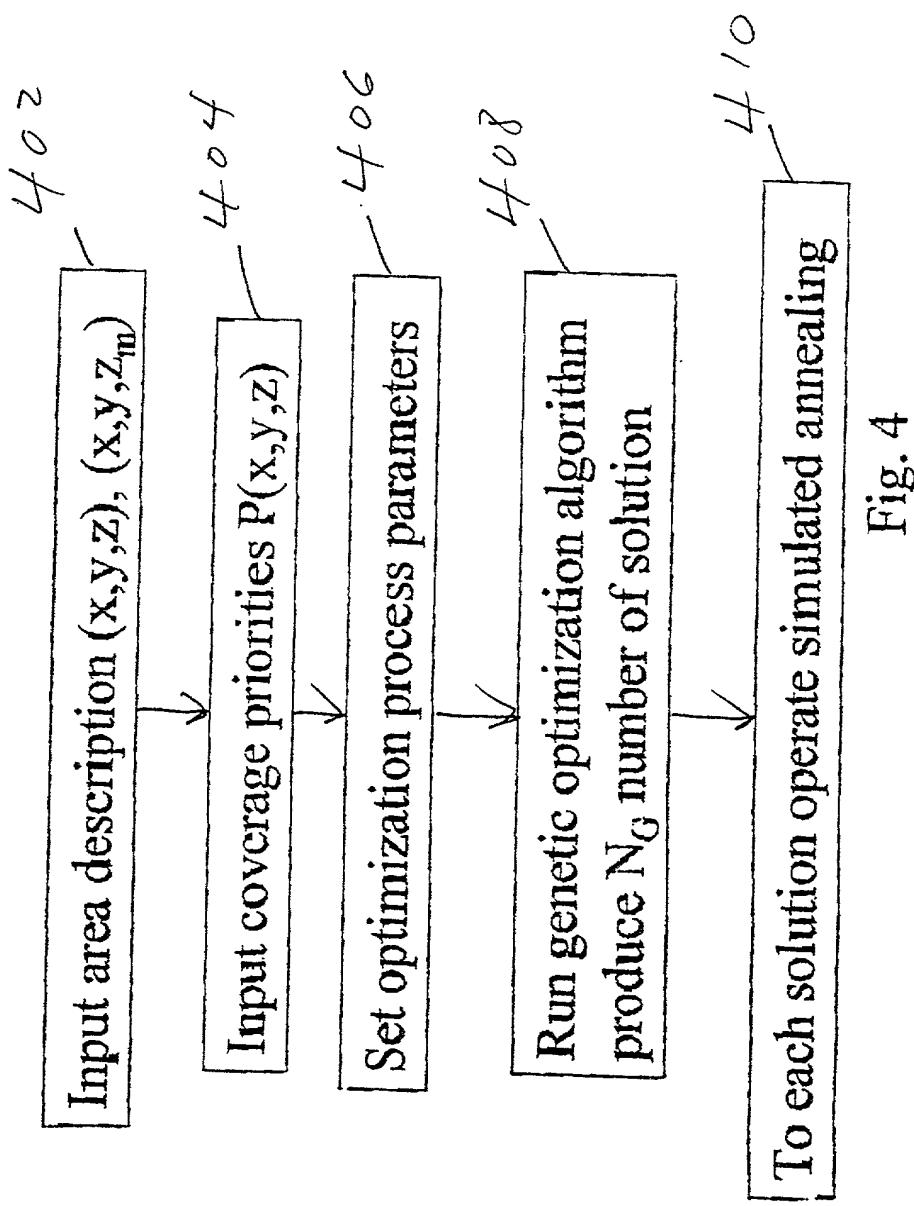
Fig. 4
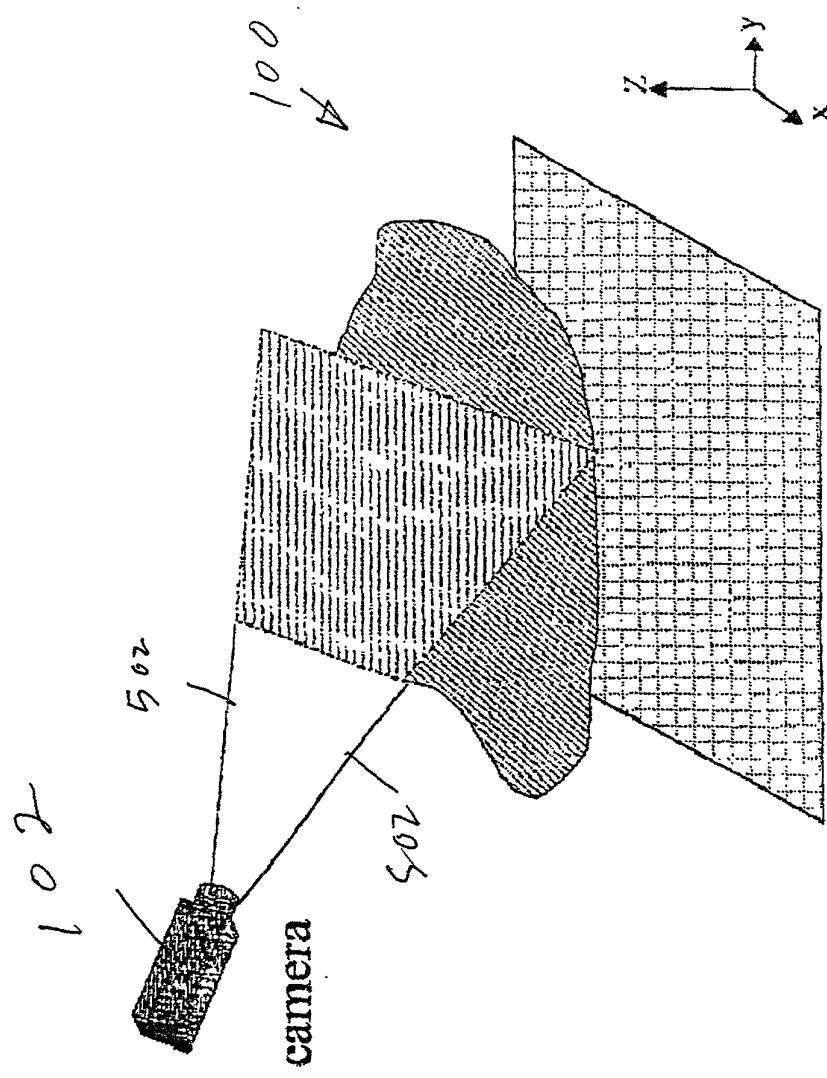
Fig. 5
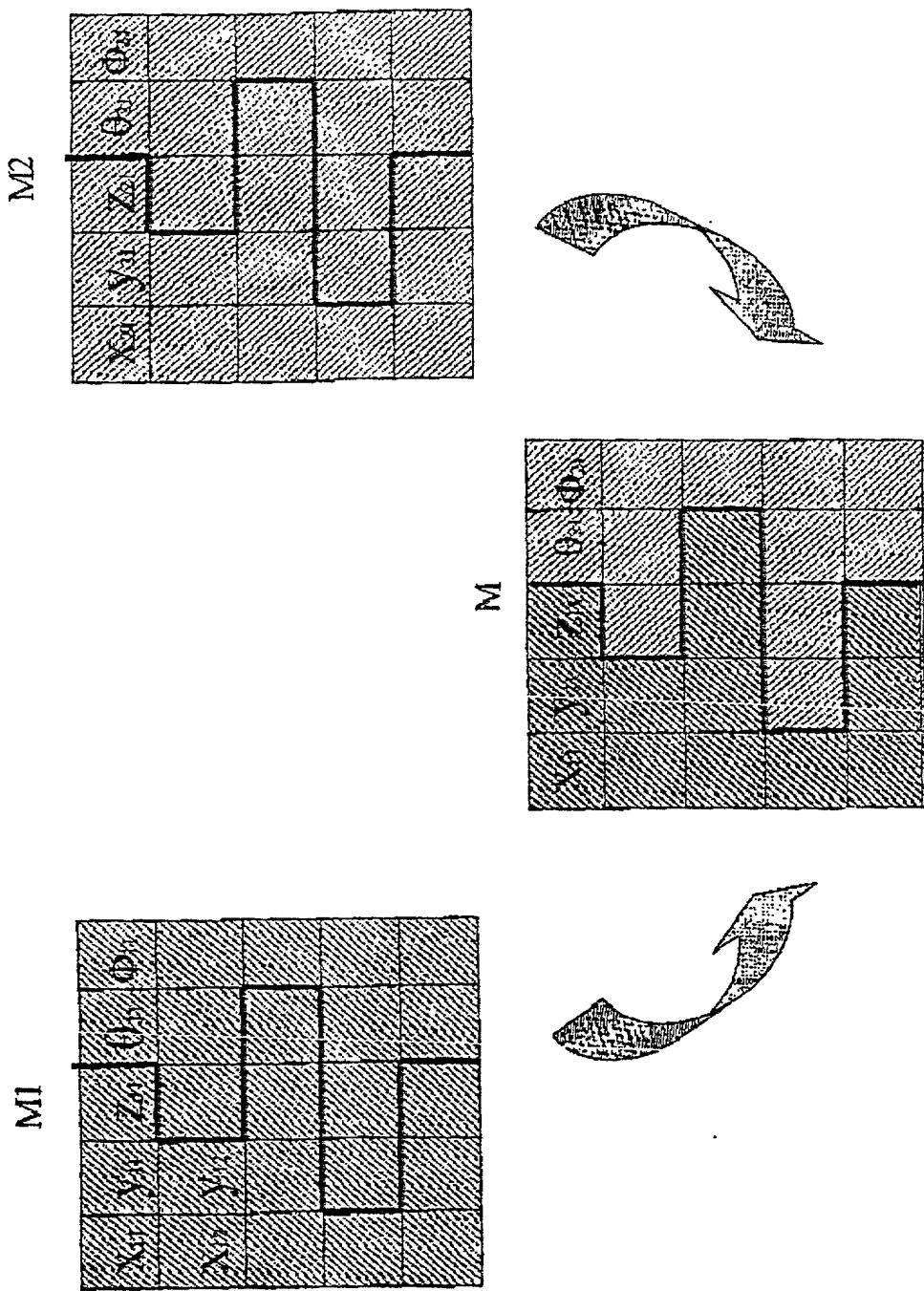
Fig. 6

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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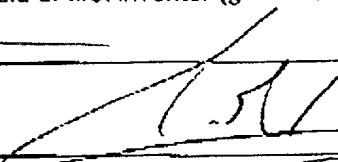
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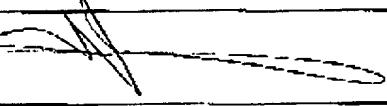
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DECLARATION FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, mailing address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: Method for Optimization of Video Coverage

the specification of which

☐ is attached hereto

☒ was filed on   17 March 2000   as United States Application Number or PCT International

Application Number   PCT/US00/40011   and (if applicable) was amended on

I hereby authorize our attorneys to insert the serial number assigned to this application.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR §1.56.

I hereby claim foreign priority benefits under 35 U.S.C. §119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 USC §119

APPLICATION NO.	COUNTRY	DAY/MONTH/YEAR FILED	PRIORITY CLAIMED

I hereby claim the benefit under 35 U.S.C. §119(e) of any United States provisional application(s) listed below.

PROVISIONAL APPLICATION(S) UNDER 35 U.S.C. §119(e)

APPLICATION NUMBER	FILING DATE
60/124,931	18 March 1999

I hereby claim the benefit under 35 U.S.C. §120 of any United States application, or §365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. §112.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR §1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

PRIOR U.S./PCT INTERNATIONAL APPLICATION(S) DESIGNATED FOR BENEFIT UNDER 35 U.S.C. §120

APPLICATION NO.	FILING DATE	STATUS — PATENTED, PENDING, ABANDONED

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith: Herbert Cohen, Reg. No. 25,109; Victor M. Wigman, Reg. No. 25,201; George C. Myers, Jr., Reg. No. 27,040, Donald R. Greene, Reg. No. 22,470; Michael C. Greenbaum, Reg. No. 28,419; Charles R. Wolfe, Jr., Reg No. 28,680; Michael D. White, Reg. No. 32,795; Brian C. Jones, Reg. No. 37,857; David J. Edmondson, Reg. No. 35,126; Denise C. Lane, Reg. No. 42,780; Peter Weissman, Reg. No. 40,220; and Rafael Perez, Reg. No. 46,041.

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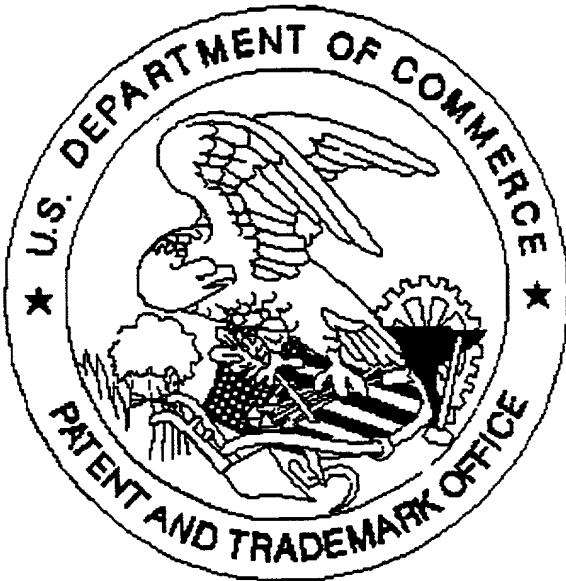
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